



# **Far Detector Assembly Block Pivot Table Design WBS 2.9.1.4**

June 5, 2007

Dave Pushka



# Block Pivot Table Requirements

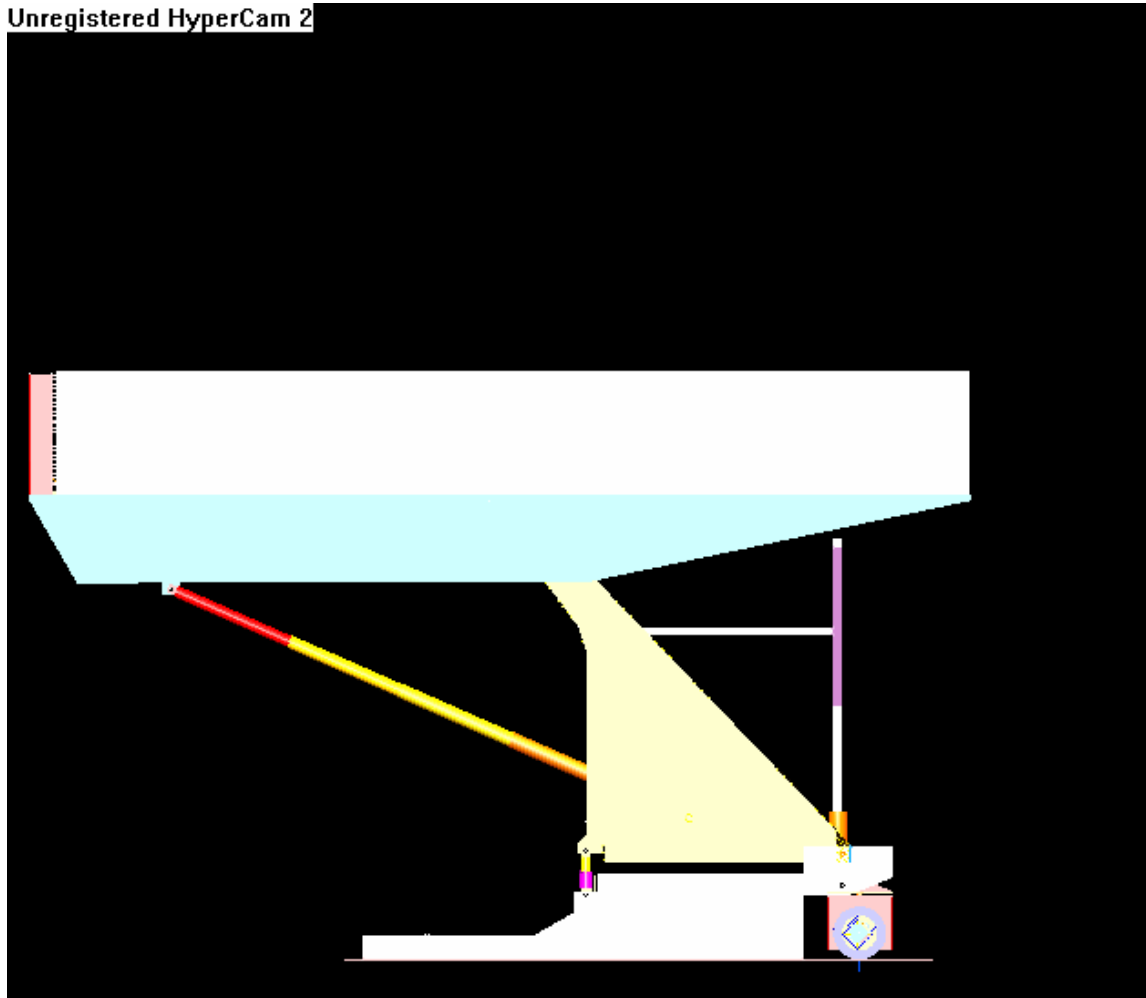
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- Provide a Horizontal Surface for Block Assembly
- Move a Completed Block from the assembly area to its position on the detector
- Rotate a Completed Block from a horizontal to a vertical position
- Disengage from a Placed Block, Return to Assembly area and repeat.
- Specifics are in NOvA note 113



# Block Pivot Table Pivoting

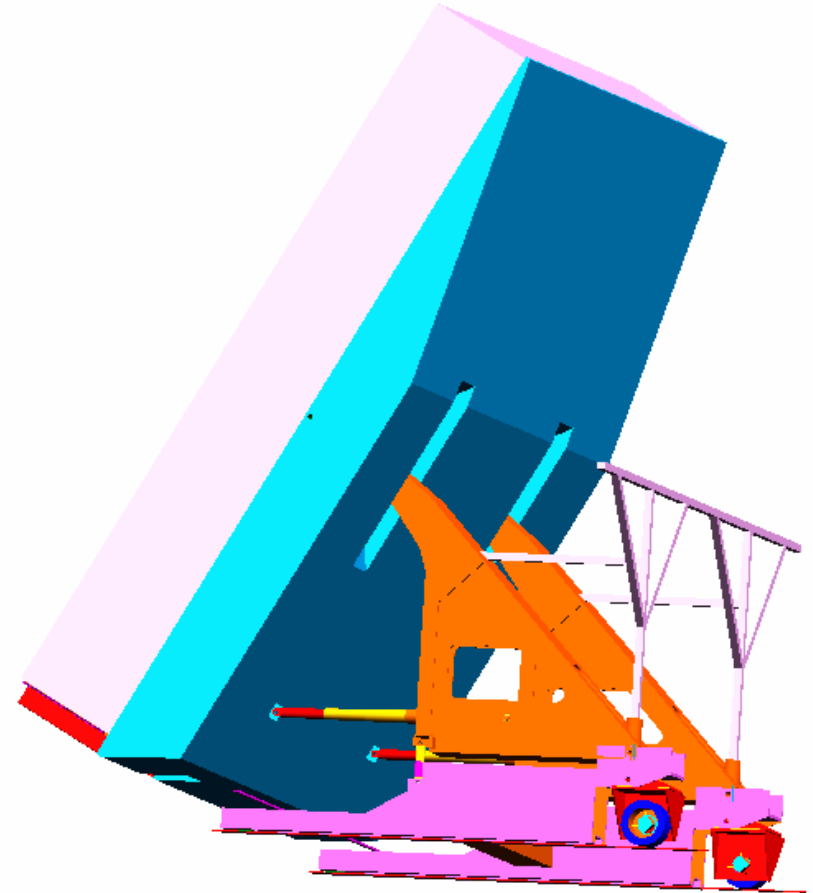
Unregistered HyperCam 2





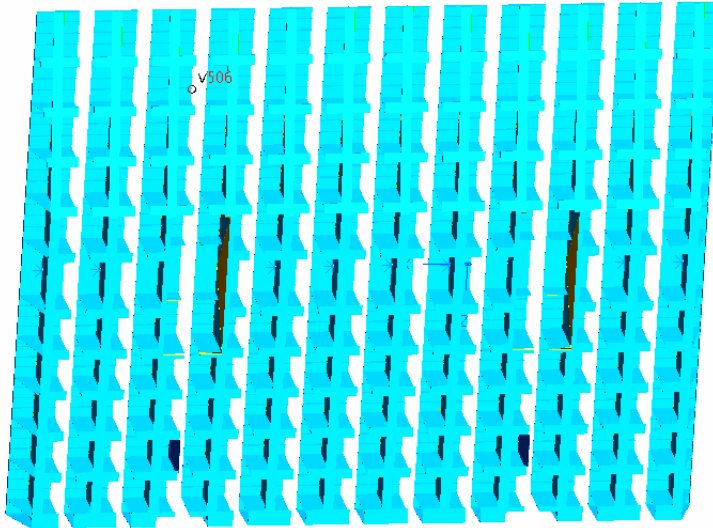
# Block Pivot Table Components

- Detector Assembly Table
- Upper Support Frames
- Lower Support Frame
- Lower Frame Brace
- Pivot Cylinders
- Kneeling Cylinders
- Horizontal Drive Elements
- Rear Table Support
- Pallet
- Rolling Elements
- Rail





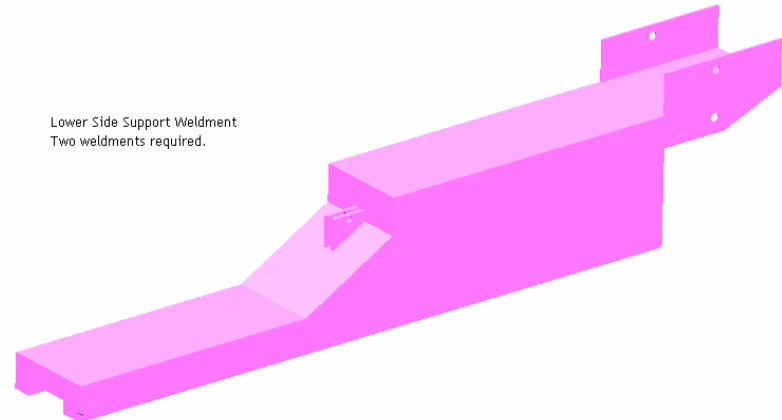
# Images of Key Components



Bottom Exploded View of Table Structure showing the 12 individual 640" long by 52" wide weldments

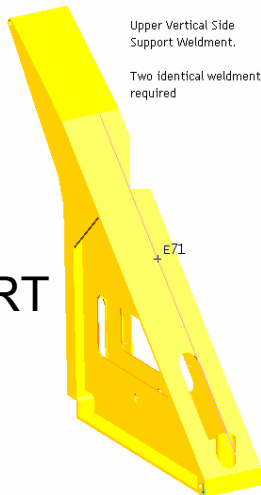
**ASSEMBLY TABLE SHOWN  
EXPLODED 12 WELDMENTS**

Lower Side Support Weldment  
Two weldments required.

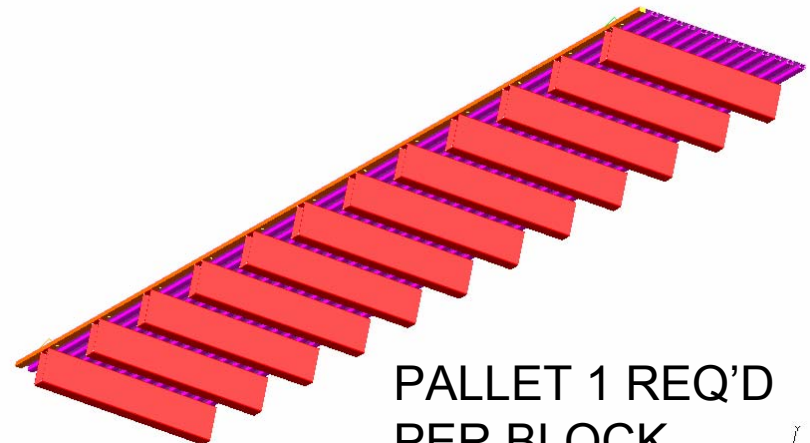


**LOWER SIDE SUPPORT WELDMENT  
2 REQ'D**

Upper Vertical Side  
Support Weldment.  
Two identical weldment  
required



**UPPER  
VERTICLE  
SIDE SUPPORT  
WELDMENT  
2 REQ'D**



**PALLET 1 REQ'D  
PER BLOCK**



# Block Pivot Table Design & Fabrication Process Steps

- Write Requirements Document (Done).
- Develop Conceptual Design (Done).
- Prepare Cost Estimate based on the conceptual design (Done).
- Conduct Internal Review (In-Progress)
- Perform Engineering analysis to size members and develop the final design. Generate engineering notes (in process). Identify and correct any safety or performance hazards.
- Prepare part fabrication drawings and perform the peer review of the engineering notes concurrently. (usually performed by one person checking one engineering note).
- Initiate independent review of the design (usually performed by a committee and involves presentations as well as the signed off fabrication drawings and checked engineering notes). Identify and correct any safety hazards.
- Fabricate components (includes parts provided by outside vendors and in house shops)
- Assemble components at FNAL to confirm proper fit up, test pivot operation with a section of the table, test horizontal drive operation. Test operating procedure. Identify and correct any safety or performance hazards.
- Disassemble and ship components to far detector location
- Re-assemble and test at far detector. Re-test operating procedure. Identify and correct any safety or performance hazards at the far detector location.

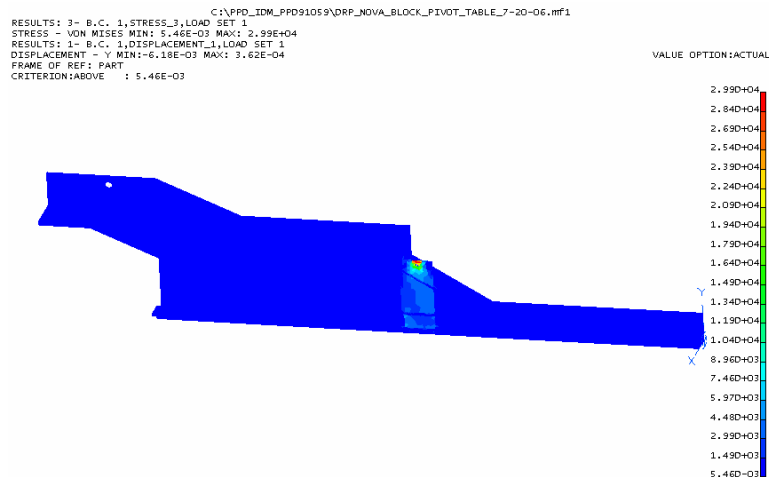
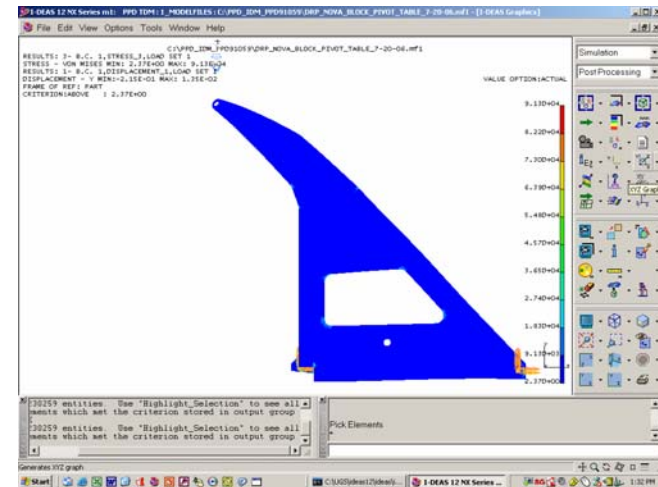
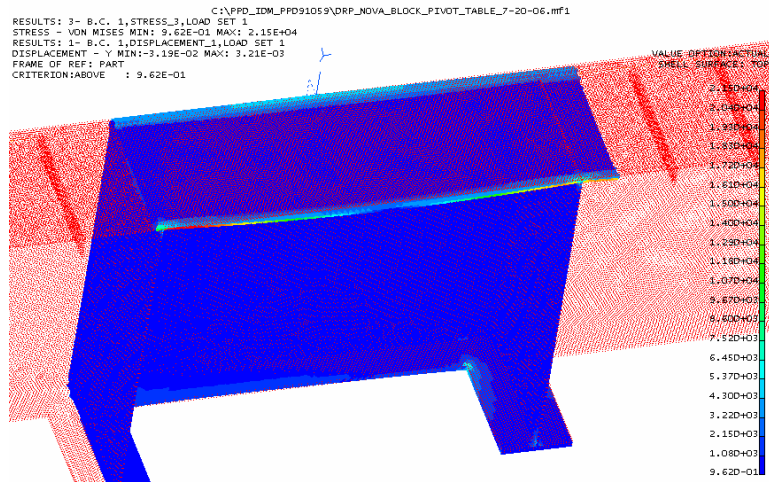


# Component Analysis Status

- Detector Assembly Table
  - Deflections when Vertical Due to Cantilevered Block using beam elements
  - Local Deflections when Horizontal due to uniform Pressure on Surface, several iterations performed (Wands, Lee, Pushka) using solids
  - Large Scale deflections modeled using beam elements (Pushka) and solid elements (Wands)
- Upper Support Frames – Static loading Condition to calculate stress and deflections. Four iterations performed using solid elements. Present design is satisfactory but not as efficient as it could be.
- Lower Support Frame – One condition, Static loading condition, using solid elements.
- Pivot Cylinders – Loads as a function of extension completed included in TDR.
- Kneeling Cylinders – Only one condition, Static loads determined
- Horizontal Drive Elements – Required drive traction estimated, used to specify the hydraulic motor and urethane tire.
- Rear Table Support – Hand calculations used to size members for static loading condition based on AISC 9<sup>th</sup> edition ASD
- Pallet – Beam element analysis completed for local and large scale deflection (Pushka) , Repeated with solid elements for same conditions (Lee).
- Rolling Elements – Hand calculations performed to size elements
- Rail – matched to rolling elements
- Internal Review Remains In Progress

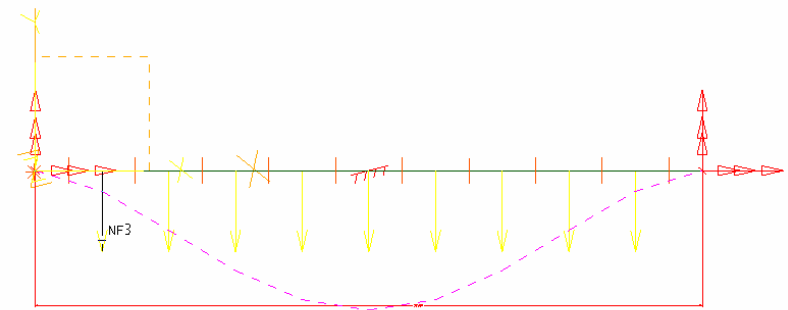


# Images of Key Components



C:\PPD\_IDM\_PPD91059\NOVA\_BOX\_BLOCK\_RAISER.mf1

DEFORMATION: 1- B.C. 1,DISPLACEMENT\_1,LOAD SET 1  
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.85E-02  
FRAME OF REF: PART





# Design Status of Key Components

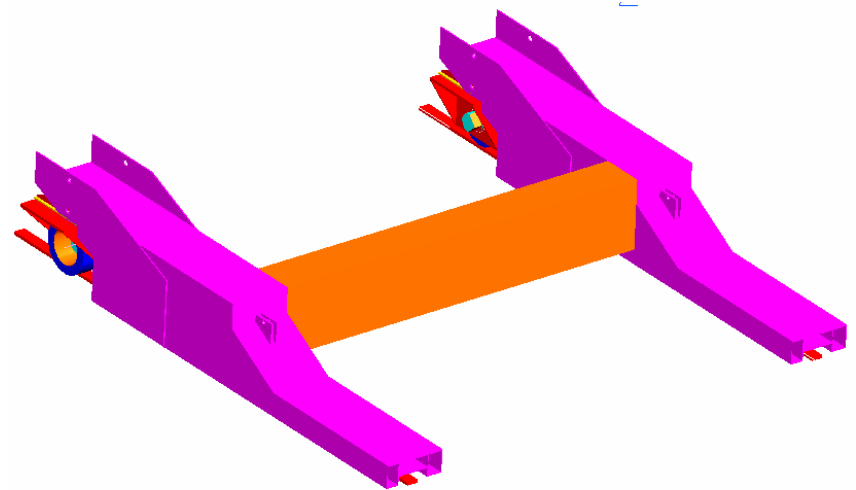
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- All Key Components have been modeled. Geometry is understood.
- All Key Components have been thru at least one analysis iteration. The Table and the Upper Supports have received multiple analysis iteration. Nearly all components have been shown to be suitable for the intended loads.
- Engineering notes and Analysis note have not yet been written.
- Fabrication drawings have not yet been started.
- Cost estimates have been prepared. Weldment costs are estimated based on the present weights of the parts. Purchased components are based on budget pricing received from vendors.



# Assembly at Far Detector

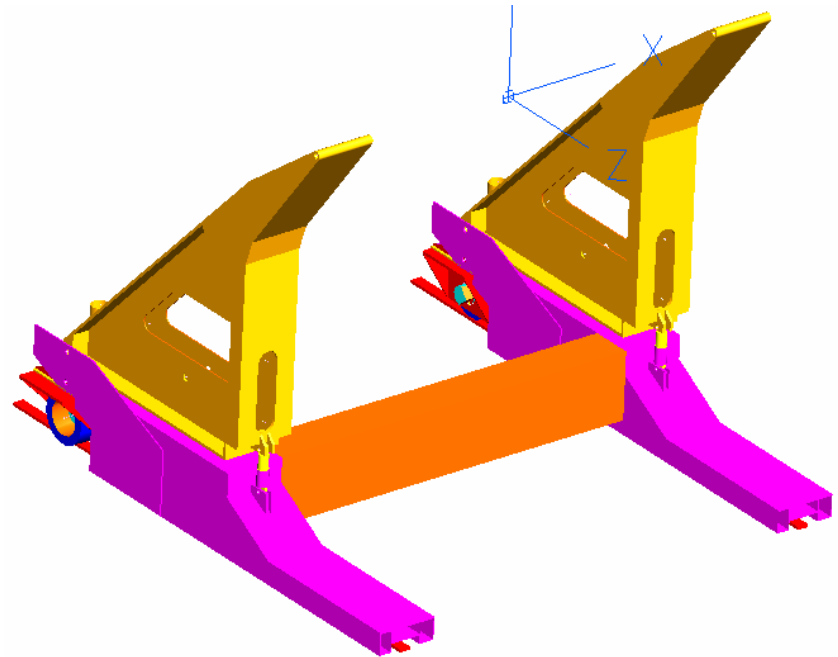
- Step 1:
  - Use 10 ton building crane to unload the following items off a flat bed trailer in loading dock area and place on the floor in the assembly area:
    - Lower Support Frame (2)
    - Lower Brace
  - Assembly two lower support frames and the lower brace:
  - Duration: 2 crew days





# Assembly at Far Detector

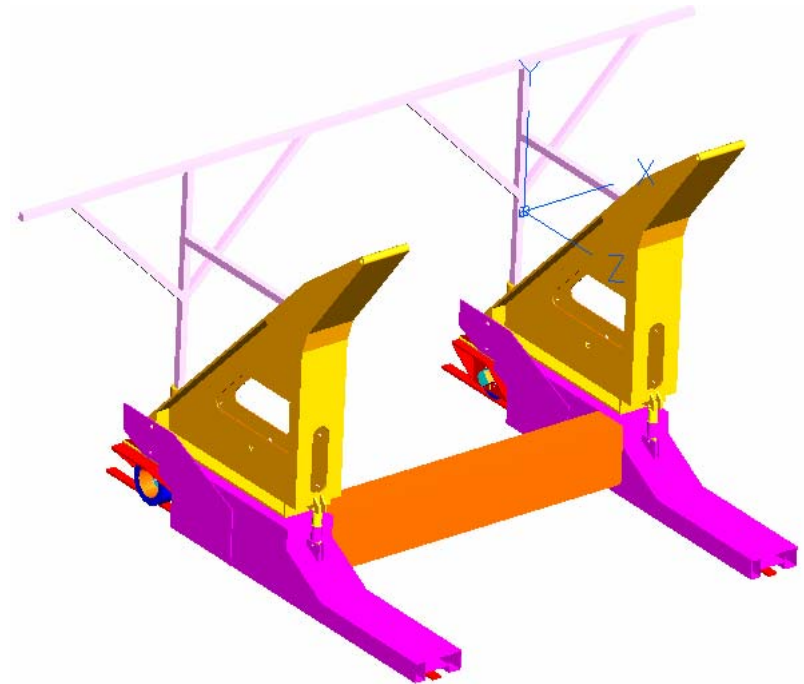
- Step 2:
  - Use 10 ton crane to unload the following items off flat bed trailers in loading dock area and place on top of the lower supports already in the assembly area:
    - Upper Support Brace
    - Kneeling Cylinder
  - Assemble to get:
  - Duration: 2 crew Days





# Assembly at Far Detector

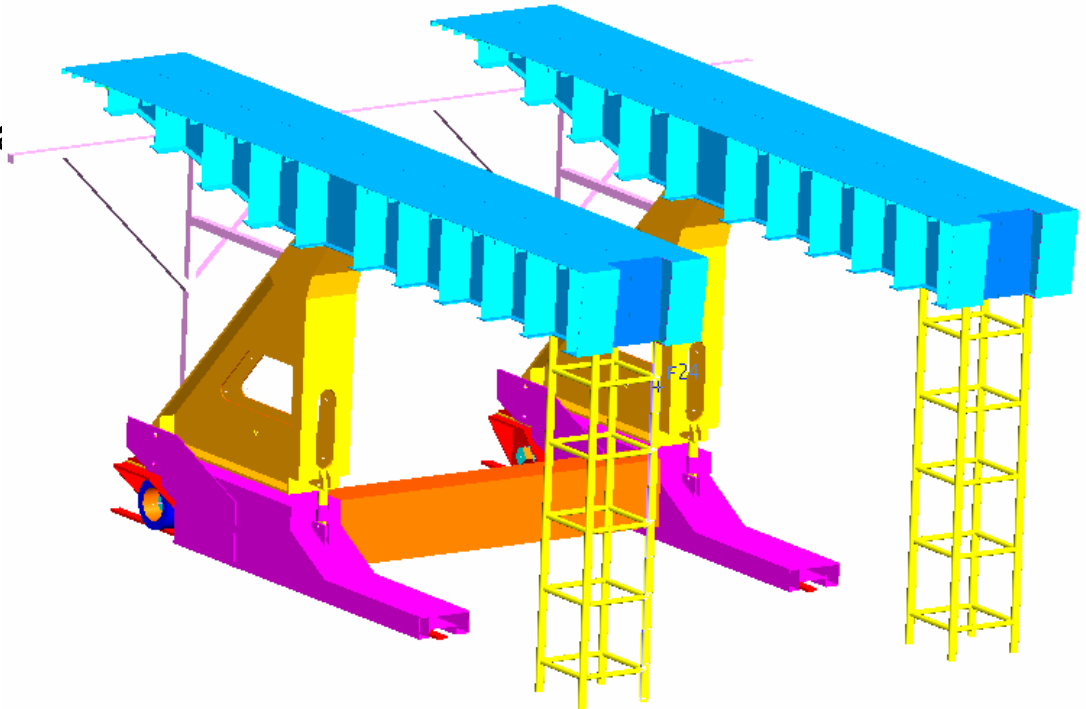
- Step 3:
  - Use 10 ton building crane to unload the following items off a flat bed trailer in loading dock area and place on the assembly:
    - Rear Table Support
  - Get:
  - Duration: 1 Crew Day





# Assembly at Far Detector

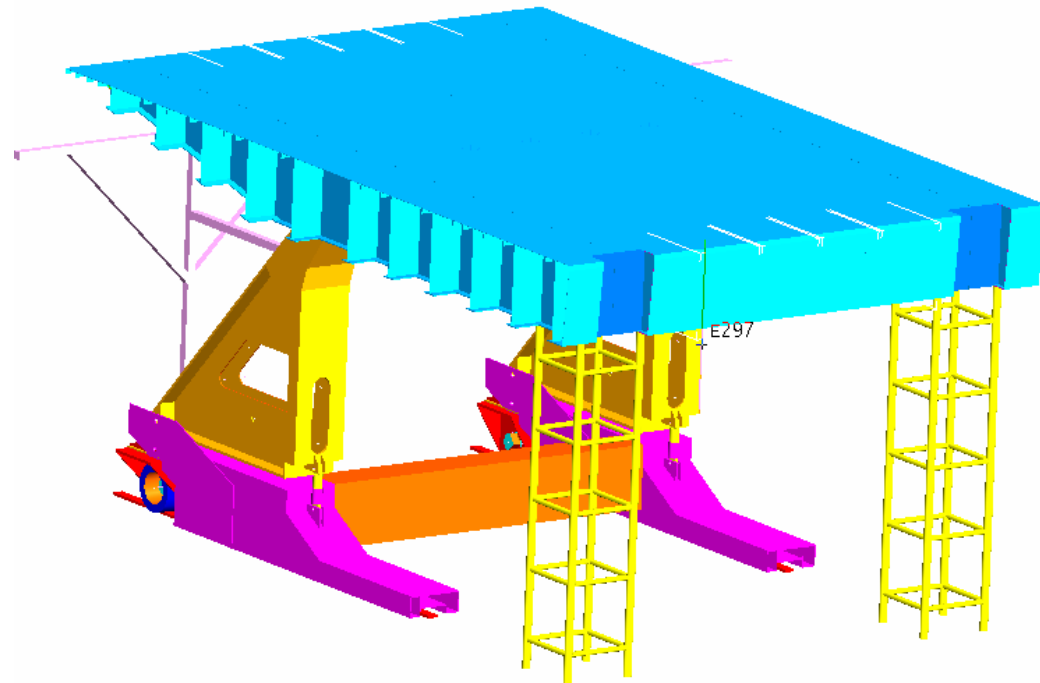
- Step 4:
  - Use 10 ton building crane to unload the following items off a flat bed trailer in loading dock area and place on the assembly:
    - Vertical Dunnage
    - Hinge sections of table (4)
  - Get:
  - Duration: 2 crew days





# Assembly at Far Detector

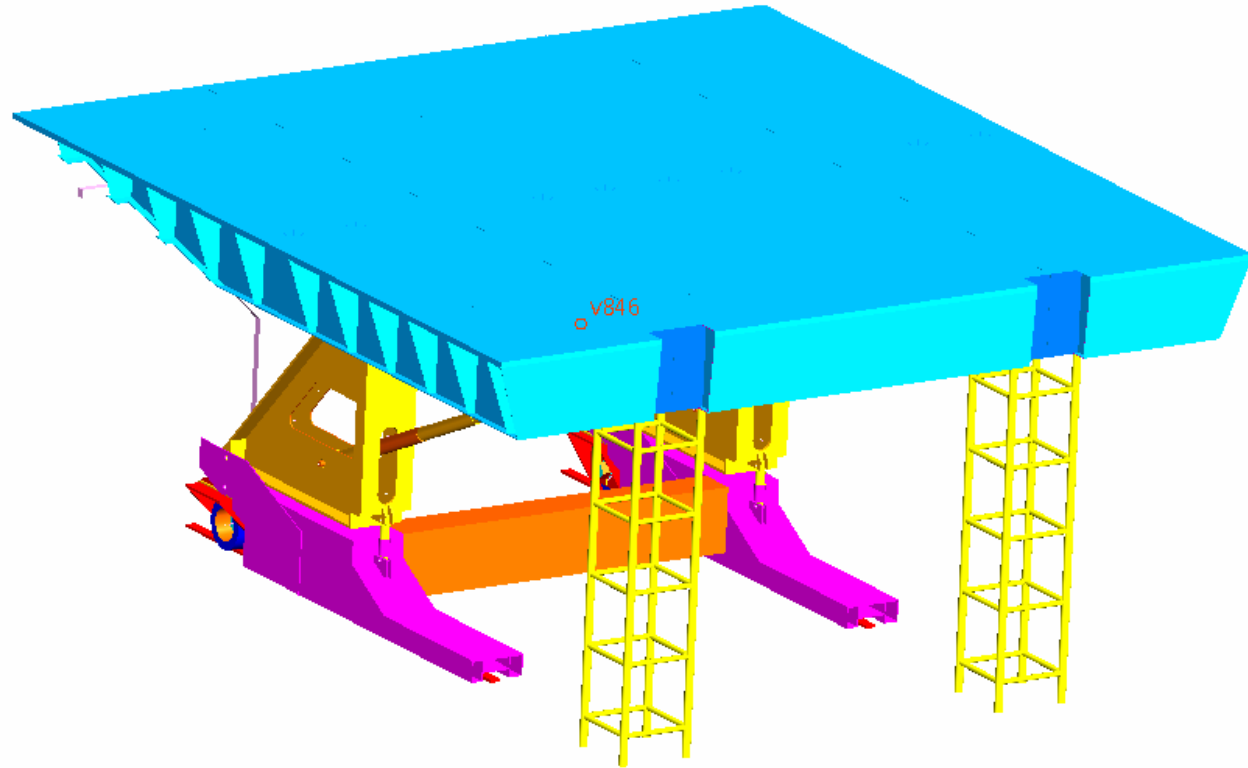
- Step 5:
  - Use 10 ton building crane to unload the following items off a flat bed trailer in loading dock area and place on the assembly:
    - Edge sections of table (4)
  - Weld to Get:
  - Duration: 6 Crew Days





# Assembly at Far Detector

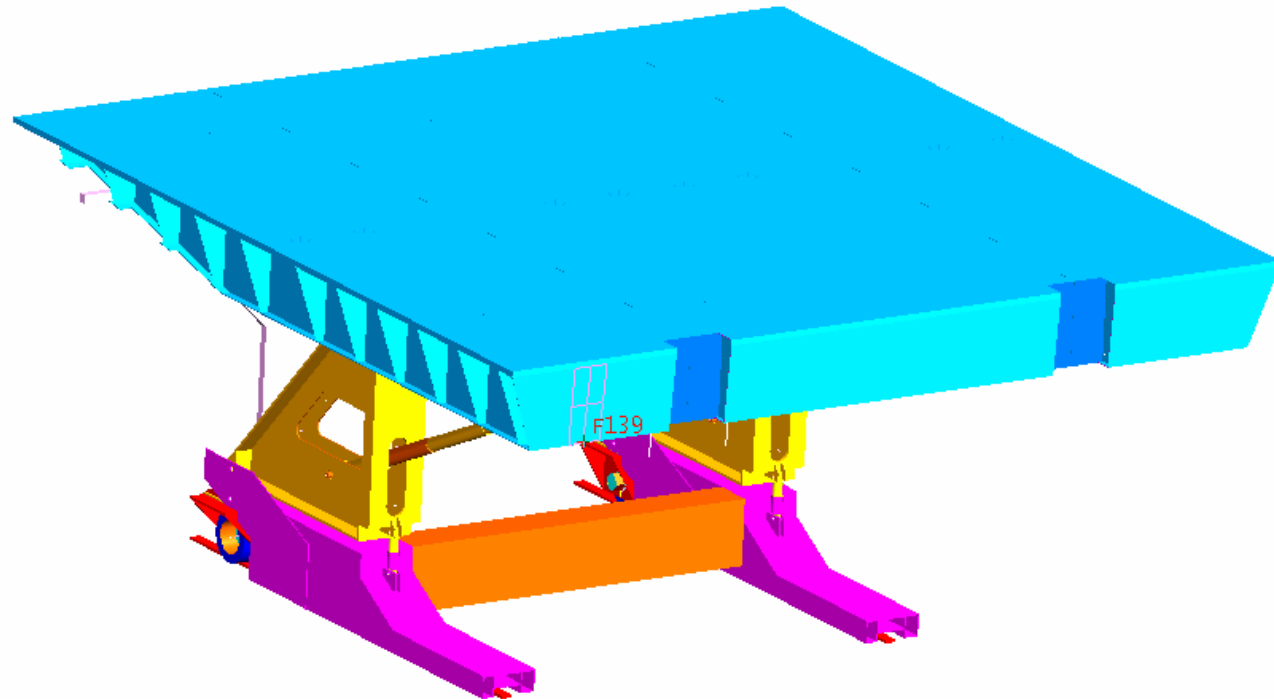
- Step 7:
  - Connect Pivot Cylinders
  - Duration
  - 1 Crew Day





# Assembly at Far Detector

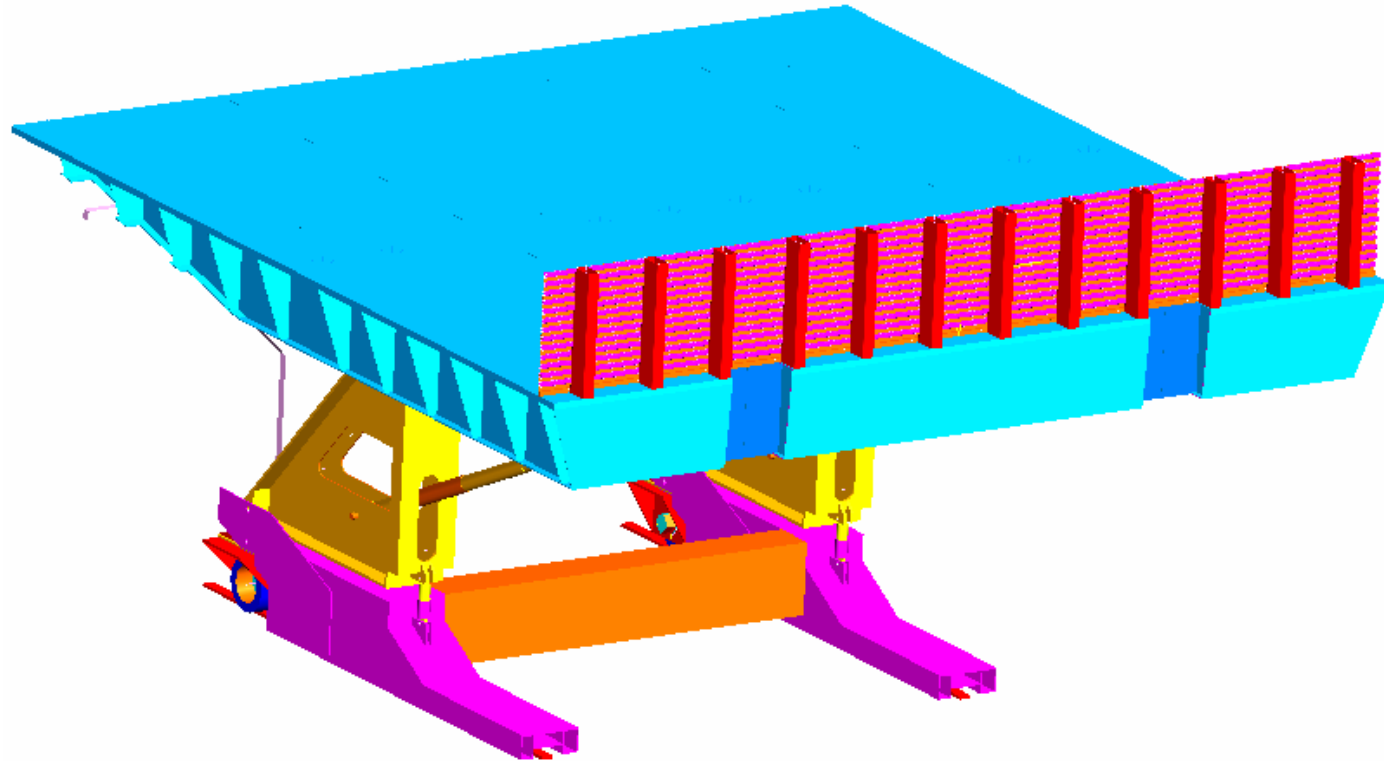
- Step 8:
  - Remove Dunnage
  - Test Operation of Pivot
  - Test Horizontal Drives
  - Install Controls
  - Duration: 2 weeks





# Assembly at Far Detector

- Step 9:
  - Install 1<sup>st</sup> Pallet
  - Duration 3 Crew Days





# Basis of Estimate

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- All Structural steel components have cost estimates based on a raw cost of steel at \$50/cwt. Cutting cost estimated based of recent Minerva plate cutting costs. Welding quantity take offs completed and used to confirm weight based fabrication cost estimates are sensible.
- Purchased components (cylinders, hydraulic drives, rollers) based on budget quotations from vendors.
- Cost for controls (interlocks, safety) based on catalog pricing for hardware. Engineering estimate for fabrication.
- Costs dominated by steel.



# Basis of Estimate

Item#	Description	Units	Unit Cost	Total Cost	Basis
1	Structural Plate 1/4" A36	119400	\$ 0.50	\$ 59,700	Faxed Quote from Ryerson November 2006
2	Structural Plate 1/4" Cutting to shape	12	\$ 380	\$ 4,560	Extrapolated from MINOS Far Detector experience at \$180 per plat for 1/2 inch material, ~ 25 feet long
3	Structural Plate for Vertical Members	60000	\$ 0.50	\$ 30,000	Faxed Quote from Ryerson November 2006 (using same cost per pound as the 1/4" material)
4	Telescoping Cylinders – Central Hydraulics	2	\$ 10,000	\$ 20,000	Quote from Sept 05, Escalated and extrapolated for longer extension
5	Drive Hydraulic Motors	2	\$ 12,000	\$ 24,000	Quote from Flodyne/Hydradyne in February 2007
6	Drive Wheel and Tire Assemblies	4	\$ 1,995	\$ 7,979	Quote from Superior Rubber and Tire in December 06
7	Lowering Cylinders	2	\$ 732	\$ 1,464	2.5" stroke, 100 ton cylinder catalog pricing from McMaster-Carr Item # 2945T21
8	100 metric ton Hilman Rollers	2	\$ 1,238	\$ 2,476	Quote from Hilman Roller Nov 2006
9	200 metric ton Hilman Rollers	2	\$ 2,467	\$ 4,934	Quote from Hilman Roller Nov 2006
10	Main Pivot Bearings	6	\$ 1,145	\$ 6,870	Telephone Quote from Bearing Headquarters 9-05
11	Hydraulic Pump and Reservoir – Flow Products	1	\$ 9,492	\$ 9,492	Copied from Vic's Note. Assume this is a conservative estimate for the smaller pivoter cylinders
12	Shipping Fixtures	0	\$ -	\$ -	Not required, sections fit on a standard flat bed truck, with
13	Table Shop Welding Costs	12	\$ 10,169	\$ 122,027	Estimated by calculating the length of weld and applying a dollar per foot unit cost.
14	Table Shop Welding Fixturing	1	\$ 10,000	\$ 10,000	Estimated based on using existing magnet assembly tables leveled to provide a flat surface
15	Table Field Welding Costs	1	\$ 7,779	\$ 7,779	Estimated by calculating the length of weld and applying a dollar per foot unit cost.
16	Table Field Welding Fixturing	1	\$ 10,000	\$ 10,000	Estimated by calculating the length of weld and applying a dollar per foot unit cost.
17	Vertical Weldment Welding Costs	2	\$ 1,804	\$ 3,608	Estimated by calculating the length of weld and applying a dollar per foot unit cost.
18	Hydraulic Controls	1	\$ 30,000	\$ 30,000	Estimate based on Catalog pricing for an Automation Direct PLC with Several I/O
19	Vertical Assembly Dunnage	2	\$ 10,000	\$ 20,000	2000 pounds of steel per unit. Assume \$5 per pound for fabricated material.
20					
21	Miscellaneous Items omitted above	1	\$ 100,000	\$ 100,000	
	Total			\$ 474,888	